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		23FEB04 E875085-1 000027 P01/7700 0.00-0403853.5 NONE
2.	**Patent application number** *(The Patent Office will fill in this part)*	0403853.5 — 20 FEB 2004
3.	**Full name, address and postcode of the or of each applicant** *(underline all surnames)*	Pelikon Limited Trecenydd Business Park Caerphilly Wales CF83 2RZ
	Patents ADP number *(if you know it)*	8337792002
	If the applicant is a corporate body, give country/state of its incorporation	United Kingdom
4.	**Title of the invention**	Improved Displays
5.	**Name of your agent** *(if you have one)*	Frank B. Dehn & Co.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	179 Queen Victoria Street London EC4V 4EL
	Patents ADP number *(if you know it)*	166001
6.	**Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months**	**Country** / **Priority application number** *(if you know it)* / **Date of filing** *(day / month / year)*
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Continuation sheets of this form	
Description	10
Claim*(s)*	4
Abstract	2
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Priority documents	
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Signature **Date** 20 February 2004

12. **Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom**

Robert Jackson
020 7206 0600

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83613.902

Improved displays

This invention is concerned with improved displays, and relates in particular to devices with displays that are activated by the mere presence of a User of the device. More specifically still, the invention is concerned with displays, such as electroluminescent displays, that are most preferably switched off, to conserve power, when not in use, and employ capacitance sensing means to detect a nearby User and so enable activation ready for use.

Certain materials are electroluminescent - that is, they emit light, and so glow, when an electric field is generated across them. The first known electroluminescent materials were inorganic particulate substances such as zinc sulphide, while more recently-found electroluminescent materials include a number of small-molecule organic emitters known as organic LEDs (OLEDs) and some plastics - synthetic organic polymeric substances - known as light-emitting polymers (LEPs). Inorganic particulates, in a doped and encapsulated form, are still in use, particularly when mixed into a binder and applied to a substrate surface as a relatively thick layer; LEPs can be used both as particulate materials in a binder matrix or, with some advantages, on their own as a relatively thin continuous film.

This electroluminescent effect has been used in the construction of displays. In some types of these a large area of an electroluminescent material - generally referred to in this context as a phosphor - is provided to form a backlight which can be seen through a mask that defines whatever characters the display is to show. In other types there are instead individual small areas of EL material. These displays have many applications; examples are a simple digital

time and date display (to be used in a watch or clock), a mobile phone display, the control panel of a household device (such as a dishwasher or washing machine), and a hand-holdable remote controller (for a television, video or DVD player, a digibox, or a stereo or music centre).

A problem with electroluminescent displays is that they are rather profligate with power; another is that they have a relatively short life - possibly as little as 1000 hours. Accordingly, when they are used the device of which they are a part is normally arranged to turn the display off when it is not required. This means, of course, that when their use *is* required they must first be activated, or turned on, and while it is perfectly possible for the User him- or herself manually to achieve this it would be advantageous were the display to be turned on automatically. It is this, the automatic activation of the display, that the present invention seeks to facilitate. And in order to attain this end the invention proposes that the display - or, rather, the controlling circuitry with which the display is associated - be able to use capacitance effects to determine the near presence of the User, and specifically of the User's hand as the device is picked up, and to utilise this to effect activation of the display.

In one aspect, therefore, this invention provides a display of the type having both an activated, "on", state and an inactivated, "off", state, and being switchable between the two, which display incorporates a capacitance sensor, able to detect the near presence of a User, together with means able to utilise the output of this sensor to effect activation of the display accordingly.

The display can be of any sort, and used with any variety of device. It could, for instance, be a

light-emitting diode (LED) display, or it could be a backlit liquid crystal display (an LCD) or even a thin film transistor (TFT) display as used in computer screens. However, the invention is of particular value when applied to displays using electroluminescent materials to provide the light output, which displays need to be switched off when not in use in order to conserve power and extend their useful working life. A typical such electroluminescent display is that employed in a remote (hand-held) controller for, say, a television.

In the invention the display - by which term is here meant the combination of the actual display together with its controlling circuitry - incorporates a capacitance sensor, able to detect the near presence of a User. In this context a capacitance sensor is, in effect, little more than a pair of spaced electrodes plus suitable electronics able to measure the capacitance of the pair and to output some sort of signal in dependence thereon. The pair's capacitance is determined by the size of the electrodes, by the distance between them, and by the electrical nature of the medium between them; a near body, particularly such a body at earth/ground potential (such as the User's hand), will strongly affect the latter, and the resulting change in capacitance, and relevant output signal, can be sufficient to allow its use for switching the display, as required.

Where the capacitance sensor does indeed utilise a pair of electrodes, then these can be positioned anywhere suitable relative to the display. Where the display of the device in question is an electroluminescent display, and such a display has, as is usual, a front electrode for activating the display's light-emitting areas, then one electrode of the pair is most conveniently that front electrode, the other being either the case of the device or one

of the power terminals of the circuit driving and controlling the device and its display. The ground (earth) terminal is a preferred choice, particularly if the case is grounded, as - in a hand-held device such as a remote controller, for example - this will couple to the User holding the device better than other parts of the system. The use of the front electrode of the display removes the need to add extra electrodes to the system specifically for the purpose of capacitance sensing; however, if preferred an extra electrode can be added specifically for the purpose of making the capacitance measurement.

For displays which operate with the front electrode at a high voltage, some protection - a suitable diode, for instance - can be added to safeguard the sensor electronics therefrom when the display is operating.

The invention employs a capacitance sensor able to detect the near presence of a User. More specifically, the sensor detects a change in the capacitance of a pair of spaced electrodes that is effected when a User either picks up the device of which the display is a part and/or touches the display panel. The capacitance may either increase or decrease, depending on the design of the device in question, and the electrodes between which the capacitance is measured. In an example discussed in more detail hereinafter, the capacitance increases.

The display of the invention incorporates a capacitance sensor together with means able to utilise the output of this sensor to effect activation of the display accordingly. In general, the manner in which the sensor's output is used to effect display activation may be any that is convenient. However, one particular method involves measuring the time taken to charge the capacitance to a specific value (a threshold value; this threshold level could be the

threshold level of an input into a microcontroller, a comparator or any other suitable device). Clearly, the bigger the capacitance the longer it takes, and by frequently discharging and then charging the capacitance, and comparing the charging times, so there can quite simply be determined when - as by picking up the device - a User has come near to the display.

To explain this in more detail the invention is now described as the measurement of a test capacitance between the front electrode of a display device and the ground point of the device. As noted, the system for measuring the test capacitance involves charging the test capacitance under the control of a microprocessor, and making a measurement of the time taken for the voltage on the test capacitance to reach a threshold level.

For battery powered applications it is preferable to minimise the power consumption of the capacitance measurement system in order to maximise battery life. As the test capacitance will be very small, it will not require a large amount of charge to reach the threshold voltage, so this is not an important consideration in reducing power consumption (indeed, the power consumption of the microcontroller device used to control the capacitance measurement in the period over which the measurement is made will usually be greater than the power consumed in charging the capacitance!). The critical issue is to make the measurement as quickly as possible, and therefore reduce power consumption, while also making an accurate measurement which can distinguish small changes in the test capacitance. In order to achieve this, a system of two or more charge rates may be used. By way of example, a system using two charge rates - the dual ramp system - is described here.

The test capacitance is first charged at a high rate for a fixed period of time chosen so as rapidly to charge the capacitance to a voltage close to the threshold voltage in a very short time (within, for example, 1 to 50 microseconds). The capacitance is then charged at a significantly lower rate until the required threshold voltage is reached (the rate of the slow ramp determines the variation in capacitance which can be distinguished by timing of the slow ramp). The time taken for the slow ramp charge period thus to charge the capacitance gives a measurement of the size of the capacitance.

The microcontroller filters the time taken for the slow ramp to charge the capacitance to the threshold voltage, taking the average of a number of measurements in order to reduce noise. A large change in the slow ramp time, i.e. a change that is larger than the usual level of random noise in the capacitance measurement, will indicate a change in the test capacitance due to the presence of a User's hand or the like, and cause the microcontroller to activate the device. If the test capacitance increases, then the time for the slow ramp will increase, and if the test capacitance decreases then the slow ramp time will decrease.

In order to minimise the time for the test, and therefore to minimise power consumption, the time period for the fast ramp is adjusted by feedback from the slow ramp time. If the slow ramp time takes longer than a predetermined time, then the fast ramp time is increased by one time quantisation. This reduces the time the microprocessor is running for, and therefore reduces power consumption.

If the voltage threshold is reached on the test capacitance before the fast ramp has finished then the time period for the fast ramp needs to be decreased in

order to bring the trigger point into the slow ramp period.

In summary, then, the invention relates to devices incorporating displays, particularly electroluminescent displays, which are able to sense when they have been picked up or touched by a User, this functionality enabling the display panel of the device only to be active when the device is required by the User. Application of the invention preferably involves apparatus for making a measurement of the capacitance between two electrodes, particularly in a way such that power consumption is minimised (for battery-powered devices, in particular). The two electrodes used can be, for example, the front electrode of the display and either the case of the device or one of the power terminals of the device circuitry (the ground (earth) terminal is preferred for this, as this will couple to the User holding the device better than will other parts of the system). The electrode capacitance will be affected when a User either picks up the device and/or touches its display panel (the capacitance may either increase or decrease, depending on the design of the device in question, and the electrodes between which the capacitance is measured). If possible, the use of the front electrode of the display removes the need to add extra electrodes to the system specifically for the purpose of capacitance sensing, though of course an extra electrode can be added if desirable.

An embodiment of the invention is now described, though by way of illustration only, with reference to the accompanying diagrammatic Drawings in which:

<u>Figure 1</u> shows, mostly in block form, a circuit diagram of a display system using a capacitance sensing system according to the invention;

Figure 2 shows a graph representing the voltage in the sensing system of Figure 1 on the test capacitance against time; and

Figure 3 shows a flow chart showing the flow of system operation for the sensing circuit of Figure 1.

Figure 1 shows a circuit diagram of a display system using a capacitance sensing system according to the invention. The diagram indicates the test capacitance (TC) to be measured, two resistors (R_1, R_2) for charging the test capacitance, a protection diode (D_1), a transistor (Q_1) for discharging the test capacitance (with a resistor [R_3] for controlling the discharge current), the input (**I**) for testing for the threshold voltage, a microcontroller (CPU) for processing measurements, and the display (**D**) to be activated when a User is detected. The front electrode (FE) of the display is labelled for the case when it is used as one of the electrodes.

Figure 2 shows a graph representing the voltage in the sensing system of Figure 1 on the test capacitance against time, while Figure 3 is a flow chart showing the flow of system operation for the sensing circuit. The operation of the sensing system is now explained.

The test capacitance TC - here the capacitance between the display's front electrode FE and Ground/earth - is first charged through a resistance R_1 (typically 100 kOhms) for a fixed period of time. This time period (T_{fast}) is chosen so as to charge the test capacitance TC to a voltage close to the threshold voltage $V_{threshold}$ within a short period of time (typically between 1 and 50 micro seconds). The test capacitance TC is then charged at a slower rate through a larger resistance R_2 (typically 5 MOhms), until the required threshold voltage is reached.

The time (T_{slow}) taken for the slow ramp charge period to charge the test capacitance to the threshold

voltage as measured at input **I** gives a measurement of the capacitance of the test capacitance. The rate of the slow ramp determines the variation in capacitance which can be distinguished by timing of the slow ramp.

The microcontroller CPU filters the time T_{slow} taken for the slow ramp to charge the test capacitance to the threshold voltage. This is done by taking the average of a number of measurements in order to reduce noise. A large change in the slow ramp time - i.e. a change that is larger than the usual level of random noise in the capacitance measurement - indicates a change in the test capacitance TC due to the presence of a human hand or the like (not shown), and causes the microcontroller to activate the device (the display **D** of which the sensing system forms a part). If the test capacitance TC increases, then the time T_{slow} for the slow ramp will increase, and if the test capacitance decreases then the slow ramp time will decrease.

In order to minimise the time for the test, and therefore also to minimise power consumption, the time period T_{fast} for the fast ramp is adjusted by feedback from the slow ramp time T_{slow}. If the slow ramp time takes longer than a predetermined time, then the fast ramp time is increased by one time quantisation in order to reduce the time the microprocessor is running for, and therefore to reduce power consumption.

If the voltage threshold $V_{threshold}$ is reached on the test capacitance before the fast ramp has finished, then the time period T_{fast} for the fast ramp needs to be decreased in order to bring the trigger point into the slow ramp period.

After a measurement has been made, a transistor (Q_1) is used to pull all of the charge out of the test capacitance in order to ensure it is fully discharged before the next measurement is made. Resistor R_3 controls the current used in this

discharge. Diode D_1 is included to protect the microcontroller from the high voltages present on the front electrode FE when the display **D** is in operation.

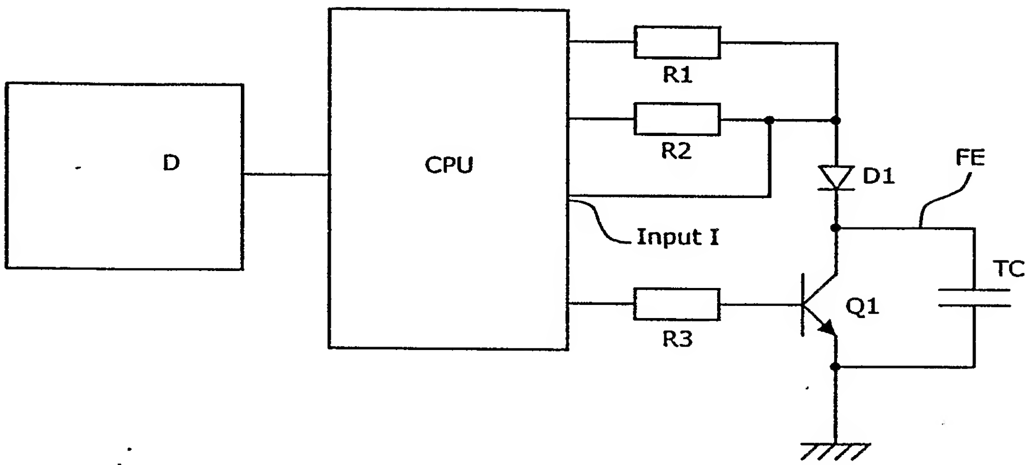

Fig 1

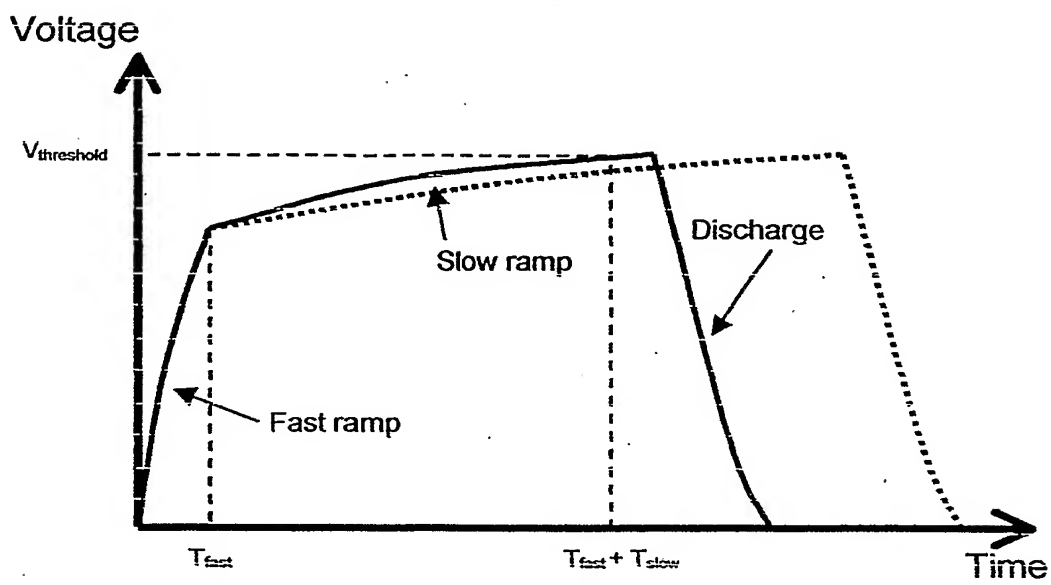
Voltage
Vthreshold
Slow ramp
Discharge
Fast ramp
Tfast
Tfast + Tslow
Time

Fig 2

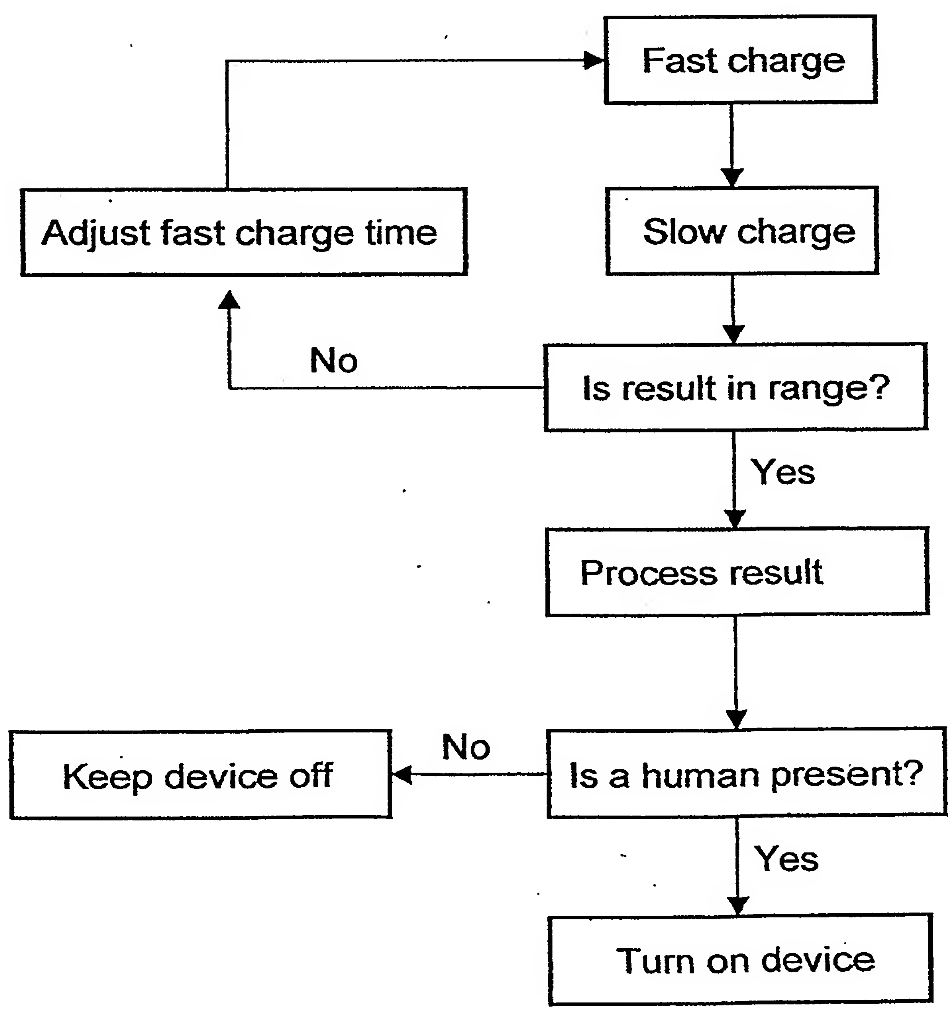
Fast charge
Adjust fast charge time
Slow charge
No
Is result in range?
Yes
Process result
Keep device off
No
Is a human present?
Yes
Turn on device

Fig 3